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Geothermal resources in Iran: The sustainable future

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ABSTRACT

Because of disadvantages of fossil fuels, renewable energy sources are getting importance for sustainable energy development and environmental protection. Among the renewable sources, Iran has geothermal energy potential. The Iranian government is considerable attention to the utilization of renewable energy, especially wind, solar and geothermal energies. Due to recent advancements in geothermal energy, many investors in the country have become interested in investing in this type of energy. Geothermal studies in Iran started in 1975 with a cooperative between the ministry of Energy of Iran and ENEL Company from Italy. Preliminary studies indicated potential for geothermal power generation in four areas in northern Iran (Khoy-Maku, Sabalan, Sahand and Damavand at Azarbaijan Gharbi, Ardebil, Azarbaijan Sharghi and Tehran provinces), respectively. Geothermal development in Iran has gained momentum in the last five years with increased exploration and industry growth in the country. Iran is developing a geothermal plant for power production. Iran government plans to build 2000 MW of renewable energy capacity over the next five years. Total projected use (geothermal capacity) has been estimated 100 MW at the end of 2010. Exploration drilling is currently in-progress for Meshkinshahr project in North-Western Iran. The Sabalan geothermal power plant is expected to produce 50 MW electric powers in 2011. The plants are planned by Iran Ministry of Energy and the Renewable Energy Organization of Iran (SUNA). This study presents a brief introduction to the resource, status and prospect of geothermal energy in Iran.

Contents

1. Introduction

World marketed energy use by fuel type shows that share of renewable energy is increasing rapidly and this trend will continue for the future. Only 1% of worldwide energy sources depend on renewable energy sources. Several scientists were studied about status and perspectives of renewable energy sources in different countries. Geothermal energy compare to the other sources of renewable energy is non-stop and steady source. It is more reliable than others. However, finding the location and excavating wells need considerable amount founds [1]. Although the geothermal energy, with its 0.3% compared to the total electricity produced worldwide plays a very minor role on the world energy scene. Due to decomposition of the internal earth's crust elements, huge amount of heat is produced. At the most subterranean layers of the earth, temperature increases so high that stones and soils are melted. If underground flowing water passes in close vicinity, it becomes hot. The water temperature sometimes even rises up to 150 °C (300 °F) when this hot water reaches the earth surface from crevices, it is called "Geyser". In most cases, lot of vapor also leaves the earth surface along with the hot water. Geothermal resources is not same everywhere and these resources mostly exist wherever there is a volcano. One of the methods of using the geothermal energy directly is house heating and also heating the green houses. This method is mostly used in the countries like Hungary and Italy.

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Table 1
Asian countries for which geothermal information exists in the international literature.

Country	Total area, km^2	Population million	GNP per capita, US/yr	Total installed electrical capacity, MW	Total electrical production, KWh/yr × 10^9	Electr. Consump. Per capita, KWh/yr	Installed geothermal electrical capacity, MW	Plamned geothermal electrical capacity, MW (2000)
Burma	678,500	45	930	1100	2.6	55		
China	9,596,960	1200	2500	162,000	746	563	32.5	81.0
Georgia	69,700	5.7	1060	4410	9.1	1526		0.5
India	3,287,590	937	1360	81,200	314	324		1.0
Indonesia	1,919,440	204	3090	12,100	44	207	309.5	1206.5
Iran	**1,648,000**	**65**	**4720**	**19,080**	**50.8**	**745**		
Israel	20,770	504	13,880	4140	23	4290		
Japan	373,835	126	20,200	205,140	840	6262	528.7	
Jordan	89,213	4	4280	1050	4.2	1072		600.0
Korea	98,480	46	11,270	26,940	137	2847		
Malaysia	329,750	20	8650	6700	31	1528		
Mongolia	1,565,000	2.5	1800	900	3.1	1267		
Nepal	140,800	22	1060	280	0.9	41		
Pakestan	803,940	132	1930	10,800	52.4	389		
Philippin	300,000	73	2310	6770	20.4	278	1444.0	
es	17,075,20	150	4820	213,100	876	5800	11.0	2291.0
Russia	0	19	9510	17,550	46	2430	0.3	110.0
Saudi	1,960,582	18	3190	1410	3.2	168	20.4	0.3
Arabia	65,610	60	5970	12,810	56.8	909		125.0
Sirlanka	514,000	63	4910	18,710	71	1079		
Thailand	780,580	74	1140	2200	9.7	125		
Turkey	329,560	15	1955	810	1.8	149		
Vietnam	527,970							
Yemen								
			Total Asia				2346.4	4415.3
			Total world				7173.5	11,025.8
		Asia: % of world geothermal capacity					33%	40%

Table 2
Different potentially geothermal regions investigated north and north-west Iran.

S. no.	Region	Estimated thermal energy (J)	Estimated mean reservoir temperature (C)	Reservoir depth (m)	Region area (Km^2)
1	Meshkinshahr	14.84×10^{18}	240	2000–3000	500
2	Sabalan (Booshli)	16.48×10^{18}	240	1500–2500	550
3	Sareine	16.65×10^{18}	140	500–1000	550
4	Damavand	5.11×10^{18}	190	2000–3000	550
5	Sehand	7.6×10^{18}	160	1500–2500	11,000
6	Khoy-Maku	30.40×10^{18}	170	2000–3000	6200

Another way of using this energy is generation of electricity. Very hot water and vapor is pumped and transferred to power plants through pipelines to start rotating and keep on moving turbines. Some of the countries such as New Zealand, America, Japan, Iceland, Turkey, Indonesia, and China. have built power plants to generate electricity from geothermal energy [2].

2. Geothermal energy in Iran

In case of Iran there is a strong political will to develop the renewable energy resources and harness the potentials. The energy resources investigated and applied in Iran are wind power, solar, thermal, geothermal, photovoltaic, biomass, biogas, hydrogen energy and fuel cell. Since Iran is a developing country with an increasing rate of electricity of consumption, in other to secure the supply of electrical energy, estimated at a growth rate of 3000 MW per year, in future renewable energy in general and geothermal energy in particular should play an important role to help the sustainable development of the country. In the long-term, geothermal energy will remain a viable option to furnish clean, reliable power in Iran. Geothermal development offers a viable energy alternation to fossil-fuel, though environmental and social impacts of geothermal development must be carefully an properly managed. Table 1 shows the geothermal information available from 22 Asian countries out of a total of 48. It is shown that by December 1996 seven Asian countries had electrical energy generated from geothermal. These countries were China, Indonesia, and Japan. Philippines, Russia, Thailand and Turkey. The installed geothermal electrical capacity of these countries was 2346.4 MW, about 33% of the world geothermal electrical capacity which was 7173.5 MW. By the year 2000 the planned geothermal electrical capacity of these 7 countries was to be 4415 MW, 40% of the world geothermal capacity estimated at 11,025 MW [3]. Among these Asian countries, from the area point of view, Iran stands to be 6th and also from the total installed electrical capacity it ranks 6th. The exploration for geothermal resources was initiated in 1975. Results indicate that Iran has substantial geothermal potential in the north and Northern provinces and there are several hot water springs, the temperature of some of which reaches to 85 °C. Company (ENEL) suggests that Sabalan (Booshli), Sehand, Damavand, Maku-Khoy and Sareine regions have promising prospects for electrical generation (Table 2).

The Center for Renewable Energy Research and Application (CRERA)-AEOI, and Ministry of Energy are investigating these regions in detail to harness this type of energy [4]. The Meshkinshahr area in Sabalan region has been selected for the first exploration drilling site (Fig. 1). The maximum temperature of local thermal springs is 83.5 °C. The geothermometry has been attempted. The investigations carried out by an Italian and best estimates are in excess of 150 °C in deep wells. Similar investigations approved 10 more potentially suitable regions for this purpose in other parts of Iran.

The Electric Power Research Center (EPRC) and Renewable Energy Organization of Iran (SUNA) were established to justify priorities of the above mentioned regions [5]. Fig. 2 shows geothermal prospects of Iran. With the experience of Meshginshahr we can write our scenario for the future and define new projects for developing a geothermal industry in Iran. There are many balneology places and tourism attractions in the Sarain area, which is located in the province of Azarbaijan. Meshkinshahr and Sarain are in the Sabalan region and the outlet of the Meshkinshahr power plant and new wells in Sarain could give us sufficient energy for direct use of geothermal energy in tourism attractions in Sabalan. Damavand field is another high enthalpy location which has been earmarked for future activity. One of the strategic future tasks in surface and drilling exploration in 14 geothermal targets (Fig. 2).

3. Previous activities

Interest in geothermal energy originated in Iran when James R. McNitt, a United Nations geothermal expert, visited the country in December 1974. In 1975, a countract among the Ministry of Energy, ENEL (Entes Nazionale per LEnergia Elettrica) of Italy and TB (Tehran Berkeley) of Iran was signed for geothermal exploration in the north-western part of Iran. In 1983, the result of investigations defined Sabalan, Damavand, khoy-Maku and Sahand regions as four



Fig. 1. The Meshkinshahr area in Sabalan region which has been selected for the first exploration drilling site [6].

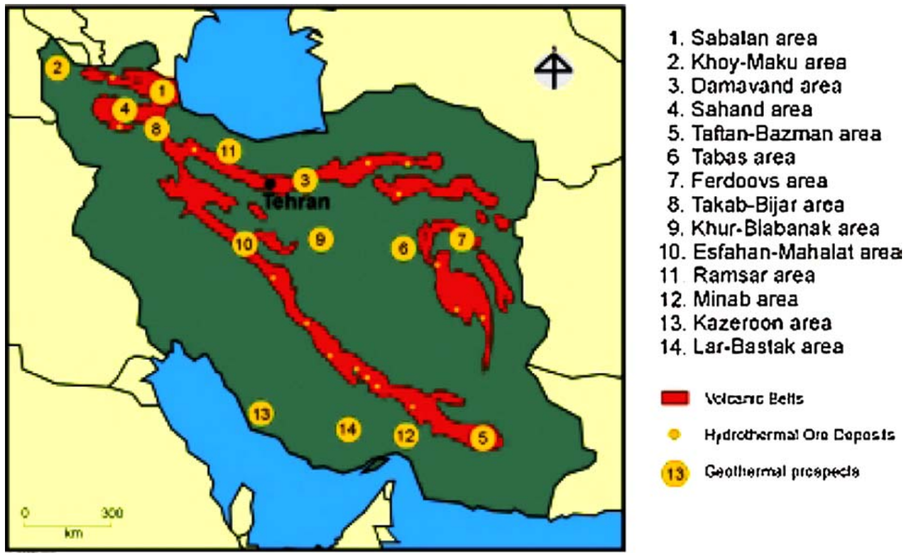


Fig. 2. Geothermal prospects of Iran [6,20].

prospected geothermal sites in northwestern Iran. Amid the 1990s, following a long gap, the growing needs to explore the clean sustainable sources of energy resulted in the setting up of specialized state-run establishments such as Electric Power Research Center (EPRC) and Renewable Energy Organization of Iran (SUNA). During recent years, the latter as an affiliate of MOE has been effectively engaged in the management and execution of a variety of renewable energy projects including geothermal projects. This company plays a fundamental administrative role in most of the nationwide geothermal projects and turns over jobs to both government and private sectors as its executive arms. Over the past decade, in parallel, SUNA has also conducted a series of countrywide potential investigation studies in order to evaluate appropriate zones for future investment particularly aiming at direct-heat utilizations in the remote areas bearing weaker economies. Ten geothermal potential sites in Iran were defined in addition to four previously defined areas in northwestern part) [6].

4. Recent work

In recent years (from 2001 onward), efforts have been made to publicize the concept of direct use for agricultural, fish farming and greenhouse purposes at the level of government authorities in Iran. A project, to publicize geothermal heat pumps, was initiated from 2004 and five geothermal heat pumps were installed in different parts of country for cooling and heating purposes. The idea of power generation from Sabalan Geothermal Prospect (Northwest Sabalan geothermal field) was initially proposed in 1994; thereafter emphasis has been put onto this field as an eminent priority. Upon detailed geo-based survey conducted by the joint collaboration of SUNA of Iran and Sinclari knight Mers Ltd. (SKM) of New Zealand within the time frame of 1998–2005, NW Sabalan geothermal field was recognized satisfactorily as a potential reservoir for power generation purposes. Based on their proposal, the exploratory drilling of three exploration wells carried out in 2002–2004. Numerical modeling of the reservoir was accomplished and the capacity of the filed was approved to install a 55-MW geothermal power plant. Development of the sabalan geothermal field is continuing with drilling of 17 more exploration and productions wells since June 2008 and 2wells are finished with promising results (February 2009) [6–13]. From 1995 up to now studies by CRERA showed that 10 promising area could be distinguished all around Iran (Fig. 3). Although by caring out of previous work it had been determined that there are two promising geothermal area, Damavand located in central Alborz covering a total area of almost 5500 km^2 and the other one Maku-Khoy region located in NW of Iran and covering an area about 6500 km^2 but due to more promising indices and effective factors in second one, main activities focused on the regions in vicinity of Sabalan Volcano and respectively Khoy-Maku geothermal area [6–19].

Surface detailed geothermal explorations (geological, geophysical and geochemical) have been carried out in the Sabalan regions. Results of feasibility studies for two zones of high geothermal potential (32×1018 J) in the Sabalan region indicate the following priority: Meshkinshahr and Sarein. According to geothermometric evaluation the average temperature of deep reservoirs are 130–250 °C. Therefore, Meshkinshahr area has the highest geothermal potential for electric generation whereas Sarein area for direct uses as indicated in Fig. 4 [15–19].

Based on Yousefi & his colleagues study, 18 geothermal prospective areas were identified. Totally 8.8% of Iran has defined as a geothermal energy potential sites. Further detailed filed. Investigations are recommended in every potential site and

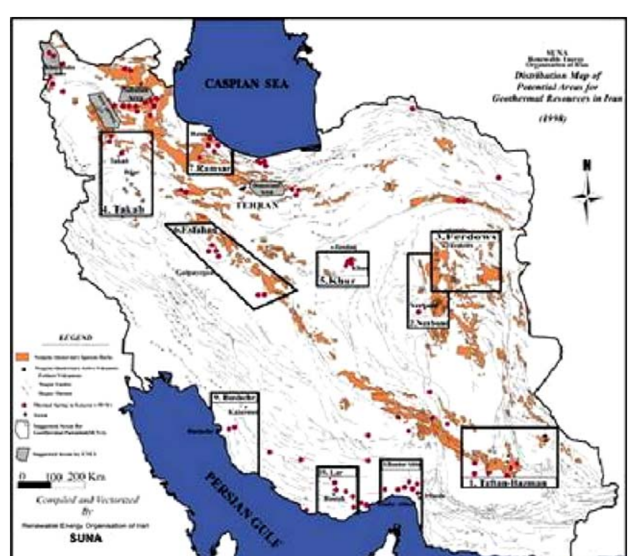


Fig. 3. Geothermal promising area in Iran [6].



Fig. 4. Iran installed geothermal power (Meshkinshahr area) that has the highest geothermal potential for electric generation and Sarein area that has potential for direct uses [6,15–19].

finally prioritizing of the sites. Fig. 5 shows geothermal potential prospected area in Iran.

5. The future of geothermal energy in Iran

Geothermal energy development in Iran faces some stiff competition. Iran has huge reserves of low-cost fossil fules, as the second largest producer of Oil in OPEC, Iran holds nine percent and 15 percent of the world's oil and gas reserves, respectively. The country's national power grid is large, with 29,000 MW of capacity of which 95% comes from fossil-fuel generation. A further 12,000 MW of capacity is planned over the 10 next years, with further expansion to an anticipated total of 90,000 MW by 2020. Against this backdrop, geothermal energy will be hard pressed to achieve a significant capacity share of Iran's overall electricity production mix. Nonetheless, the Iranian government's interest in renewable energy and geothermal resources development is growing strongly, as a way to offset some of the very high reliance of Iran's internal and export economics on fossil fuels. Provided that suitable geothermal resources can be located and developed, geothermal resources have an assured future position in the energy sector of Iran even though it is not least cost means for power



Geothermal Area	Province	Area (Km^2)
Sabalan	Ardebil	13037
Damavand	Tehran	4648
Khoy-Maku	Azerbaijan Gharbi	3257
Sahand	Azerbaijan –Sharghi	3174
Bazman	Systan& Baloochestan	8356
Taftan	Systan& Baloochestan	4310
Tabas-Ferdoos	Khorasan-Jonoobi	46628
Khor	Esfahan	2334
Tekab-Hashtrood	Azerbaijan Gharbi	4639
Mahallat-Esfahan	Esfahan-Markazi	13648
Zanja	Zanjan	3285
Avaj	Hamadan	4283
Kashmar	Khorasan Markazi	7107
Ramsar	Gilan	5532
Amol	Mazandaran	1697
Baft	Kerman	11525
Minab-Bandarabbas	Hormozgan	3191
Lar-Bastak	Hormozgan	4191

Fig. 5. Characteristics of geothermal areas in Iran [11,12].

generation and finally the immediate future of geothermal energy development in Iran is focused on assessing the suitability of the resources so far identified for either electrical power generation and/or industrial use. Regarding to above mentioned subjects it can be concluded that despite of suitable geological conditions and presence of many potential for geothermal energy productivity, due to lacking of high-tech. instruments in the field of drilling, reservoir engineering and power plant construction Iran is located at the earlier steps of this technique [6–19].

6. Conclusion

Geothermal energy will play an important role in future energy needs of Iran. It means that more study and hard work needs to get to this goal. Setting-up international collaborative business venture between Iran Renewable Energy Organization (SUNA) and private renewable energy companies is proposed as an implementation strategy in the country. Iranian government has shown strong interesting in attraction of foreign investment in last years therefore there are many opportunities to invest in geothermal field. Due to economic, environmental and new policies reasons it seems that energy production from geothermal fields in near future is inevitable. According to studies and explorations conducted by the Niroo & SUNA Research Center, the southern areas of Meshkin Shahr in the Sabalan region is the best region for the excavation of the first electricity exploration well and the subsequent development of the geothermal field for the construction of Iran's first geothermal power plant. For centuries, the residents of deprived villages in Sabalan, which is one of the coldest regions of the country, have had a difficult time providing fuel for heating and cooking. This is whilst there is a clean, cheap and ever-lasting energy resource in their area. With the utilization of geothermal energy, a new technology will make its way to that region.

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